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Flash Pasteurization Theory & Practice

Flash Pasteurization is a method of heat pasteurizing beer and other beverages prior to filling into containers for the purposes of killing spoilage micro-organisms. In this process the product is handled in a controlled, continuous flow and subjected to a temperature, normally in the range of 71.5°C (160°F) to 74°C (165°F), for a time period of 15 to 30 seconds. The amount of heat imparted into the product during the elevated temperature and time period is expressed in Pasteurization Units (P.U.'s) as defined by Del Vecchio et al, (see other useful technical information below).

When used in combination with a "Sankey" style keg and suitably adapted keg, bottle or can filling line to maintain an aseptic fill, a flash pasteurization system will accomplish an economical and microbially stable fill without impacting the beer or beverage color and flavor profiles.

Flash pasteurization has not been widely used in North America due (in part), to late 1960's and early 1970's "indifferent" trials and experiences by various brewing groups. Europe and Asia, on the other hand, adopted and use this process extensively. There are many hundreds of such systems in existence, most of which are used for kegs, some bottles and cans.

Major factors differentiating flash pasteurization from the more familiar tunnel pasteurization in the container are:

Flash Pasteurization is done prior to filling and does not have any effect on organisms introduced during filling. Therefore, a well controlled, sterile filling operation to prevent re-introduction of organisms is essential.

Flash pasteurization of beer typically uses a two or three stage plate heat exchanger with hot water as the heat exchange media. This affords the use of controlled beer flow and thin film heat transfer which assures that the beer is evenly heated by hot water temperatures 2-4°C (3.5-7°F) higher than the desired pasteurization temperature. This thin film, (or sheeting) of beer between the heat exchanger plates allows for rapid heating to higher temperatures and a short holding time at temperature, sometimes referred to as High Temperature Short Time (H.T.S.T.), then rapid cooling, all of which ensures that all of the beer receives the same P.U. input with a limited time at elevated temperatures.

EQUIPMENT:

A flash pasteurization system will generally comprise the following components:

A high head centrifugal beer pump, a triple stage plate heat exchanger with

regeneration, heating and cooling sections. An external holding tube, a re-circulating hot water set including pump and steam heating device, sterile beer tank for the pasteurized beer, process valve manifold, panel-mounted control system incorporating all the necessary instruments and controls for automatic or semi-automatic operation.

A fully automated system is typically skid mounted and includes an integral C.I.P. system to ensure the integrity of the flash pasteurization system and the filling line it serves. See the photographs in this web site.

A series of colored schematic flow diagrams of the system as described above for installation in a beer packaging operation are detailed in this web site.

The system components integrated into a skid mount design that ensure economy of space, energy efficiency, automated operation without compromising the pasteurization of the carbonated beer, regardless of internal or external process variations that might occur during operation.

Flash Pasteurization systems, including all auxiliary hardware, can typically handle flow requirements from 10 to 500 Hl./Hr.

CLEANING & STERILIZING:

Cleaning and hot water sterilizing prior to a production run is accomplished with normal 2% hot caustic cleaning regimes and sterilizing by circulating hot water at a minimum 85°C (185°F) for at least 30 minutes to sterilize the system and lines. After this period of time, the steam supply to the C.I.P./sterile liquor tank is closed off and the plate heat exchanger temperature control point is lowered to the pasteurization temperature. Cold water added to the C.I.P./sterile liquor tank and the system is allowed to cool the system as much as possible prior to introducing the glycol cooling to the plate heat exchanger. At no time must the temperature in the heating section of the plate heat exchanger and holding tube fall below the pasteurization temperature set point.

After the system stabilizes at normal operating conditions, the water is chased out with beer.

See the flow charts in this web site for an easy to follow description.

OPERATING OUTLINE:

Primary (D.E.) filtered beer at 0-1°C (32-34°F) is pushed from the cellar tank by counter pressure or a boost pump to the flash pasteurization system high head main beer pump. From this pump, the beer enters the first stage regeneration section of the plate heat exchanger (P.H.E.), where it is heated by the outgoing hot pasteurized beer on the other side of the heat exchanger plates. This "regeneration" section typically recovers 92% of the heat from the outgoing beer. The pre-heated beer then passes into the heating section where hot water raises the beer to a typical pasteurizing temperature of 71.5°C (160°F). The beer leaves the plate heat exchanger and enters the holding tube where it is held at pasteurizing temperature for a

pre-determined time interval, (normally 20 to 30 seconds).

The pasteurization temperature and hold-time are dependent upon individual beers, the live cell count and a brewer's specification to his system supplier.

After being pasteurized, the beer leaves the holding tube and returns to the second stage of the regeneration section of the P.H.E. where it gives up the heat to the incoming cold beer, This secondary pass reduces the temperature by 92% to approximately 7°C (45°F). The beer then passes into the cooling section of the P.H.E. where it is cooled by a refrigerant to the required filling temperature, usually 1-2°C (32-34°F). The beer then leaves the P.H.E. and passes to the Sterile Beer Tank (S.B.T.). The beer is then transferred to the filler by a boost pump.

Alarm functions and automatic valve control ensures that only the pasteurized beer goes to the S.B.T.. The beer is diverted back to the main beer pump suction if the S.B.T. fills or any alarm occurs. If the re-circulation of beer occurs for more than two passes through the plate heat exchanger, then it is normal practice to chase out the beer in the system to the S.B.T. and revert the system to water re-circulation. Water re-circulation is maintained under the same controlled and stable pasteurization conditions until such times as the S.B.T. level decreases.

Please refer to the series of flow diagrams in this web site for the most important operating, alarm and C.I.P. conditions. Due to size constraints, some of the flow diagram circuits have had to be omitted.

SYSTEM CONTROL REQUIREMENTS:

Major system control requirements for a beer flash pasteurization system are as follows:

Temperature control – It is essential to control both the pasteurization temperature of the beer in the holding tube and the temperature of the beer leaving the cooling section of the plate heat exchanger (P.H.E.)by utilizing a two-pen temperature recorder and controller unit. A temperature probe at the discharge of the holding tube senses the pasteurization temperature. A proportional control valve in the steam line to the hot water set controls the steam heating the hot water. The temperature recorder and controller also control the temperature of the beer leaving the P.H.E. cooling section via a proportional control valve in the coolant line.

Back Pressure Control – A system to sustain the carbon dioxide present in the beer in solution is essential. A back pressure control valve is incorporated in the system design to ensure that the system pressures at the holding tube discharge are constantly maintained at approximately 10% above the CO2 equilibrium pressure at pasteurizing temperature. (Refer to the CO2 equilibrium chart in this web site). The design of the P.H.E. plate pack also allows correctly designed pressure drops to occur as the beer passes through the second stage regeneration and chilling sections.

Flow Control – A constant flow control valve is provided. This will ensure that a constant beer flow is obtained and a magnetic flow meter with flow sensing alarm and indication is available for automatic monitoring.

A flow diversion valve system is required to prevent any un-pasteurized beer from entering the S.B.T. The valves are normally controlled by temperature and interface sensing systems and are in the form of double block and bleed arrangements.

Sterile Beer Tank (S.B.T.) Level Control – Once started in automatic, the system operates continuously at a constant flow rate. When the filler stops and the S.B.T. fills, a level control probe or load cell on the S.B.T. will indicate to the control system to put beer into a divert and/or chase out with water mode. Please refer to the series of flow diagrams in this web site.

Control console - A complete array of switches, sensors, interlocks and safeties are required. This control equipment gives visual readouts of temperature, pressure and flow to ensure that only pasteurized beer reaches the S.B.T. and filler.

OTHER USEFUL TECHNICAL INFORMATION:

A pressure/temperature/CO2 equilibrium chart is detailed to determine a flash pasteurization system operating parameters for beers with 1.0 to 4.0 volumes CO2 in solution, (1.87 to 7.48 grams per liter).

A B.T.U. thermal load chart for a 92% regeneration flash pasteurization system is detailed to determine the heating and cooling loads (in British Thermal Units – B.T.U.'s) for beer flow rates ranging from 10 to 500 Hl./Hr.

Formulae below is used for the calculation of P.U.'s and pasteurization temperature, holding time in the design of a flash pasteurization system:

In Degrees Celcius:

P.U.'s/minute = 1.3932 to the power of (T-60)

Holding time in seconds (t) = 60 x P.U.'s, devided by 1.3932 to the power of (T-60).

or;

In Degrees Farenheit:

P.U.'s/minute = 1.2023 to the power of (T-140)

Holding time in seconds (t) = 140 x P.U.'s, devided by 1.2023 to the power of (T-140).

Where: P.U. = The number of Pasteurization Units to which the beer has been exposed at the end of the holding time.

T = The pasteurizing temperature.

t = The holding time in seconds.

This information is derived from a technical paper entitled "Thermal Death Time Studies On Beer Spoilage Organisms" (A.S.B.C. Proc. 45, 1951) by Del Vecchio et al.

DETERMINATION OF PASTEURIZED BEER:

The following is a description and procedure for the determination of whether beer is pasteurized. Taken from the A.S.B.C. Proc. (1960) page 63.

PRINCIPLE: Beer, which has not been pasteurized, will contain active invertase. When sucrose is added to a beer containing invertase, the sucrose will be hydrolyzed to fructose and glucose. The presence of glucose can be detected using glucose oxidase sensitized paper strips. The presence of glucose in beer after sucrose addition indicates the beer has not been sufficiently pasteurized.

REAGENTS: A; Test tape for glucose – Eli Lilly & Co. B; Powdered sucrose.

PROCEDURE: A; Add 1g. of powdered sucrose to 5ml. of beer and allow to stand for 30 minutes at room temperature. B; Partially immerse a short strip of the test tape into the beer, withdraw from the beer and observe the color after 2 minutes. C; If the test tape turns green, the beer has not been sufficiently pasteurized. D; For color comparison, the test should be run simultaneously on an un-pasteurized beer sample.

A point to note: The American Society of Brewing Chemists (A.S.B.C.) method for the determination of whether beer is pasteurized as detailed below, only determines whether the beer is pasteurized, not by how much.

IDD CUSTOMER OPERATIONAL RESULTS:

ABITA BREWING COMPANY, LLC – Abita Springs, Louisiana:

Using a 71.5°C and 20 seconds flash pasteurization regime. Production results for bottled beer from 154 samplings were averaging <40 yeast cells/100ml., <20 lactobacilli/100ml., <20 Pediococci/100ml. prior to flash pasteurization and <1 cell/100ml. of each after flash pasteurization.

PALM SPRINGS BREWERY – Palm Springs, California:

Tests carried out with infected beer at 1.8 million cells/ml. prior to flash pasteurization. Using a 73(C and 20 seconds hold time (25 P.U.) yielded final cell counts of 6 aerobic cells/ml., <1 lactobacilli/ml. and <1 anaerobic/ml. after flash pasteurization. The brewery typically uses 71.5 to 72°C and 20 seconds for their bottle and keg beer production.

SPOETZL BREWERY – Shiner, Texas:

Used at 68°C for 20 seconds hold time (4.75 P.U.) to immobilize yeast prior to re-inoculating a new strain into bottled wheat beer. Typical cell counts are 50,000 viable yeast cells/ml., and 3 lactobacilli cells/ml. prior to flash pasteurization. After flash pasteurization the viable cell count is <1 yeast cell/ml.

ADVANTAGES:

An easily controlled automated process, when combined with the plate heat exchangers thin film concept, can be counted on to give repeatable, uniform treatment of beer passing through the system. Low oxygen levels associated with conditioned beer and the short time duration at pasteurization temperature, correctly designed and manufactured flash pasteurization systems minimize off flavors usually associated with heating beer. Lower capital and operating costs, space saving, mechanical simplicity, low maintenance cost, permanent records for Q.C. historical product checks, low energy consumption due to 92% or more of the energy in the regeneration section of the plate heat exchanger being recovered. Lightweight bottles and cans, can be used since they don't have to withstand the pressures induced by pasteurization in the package.

DISADVANTAGES:

A sanitary and sterile filling operation following flash pasteurization is necessary since it opens up possibilities for the re-introduction of beer spoilage organisms. Please refer to the bottling line sanitization system line diagram in this web site.

ACKNOWLEDGEMENTS:

My thanks and appreciation to Abita Brewing Company, Palms Springs Brewing Company, Spoetzl Brewery, Mr. Bill Anderson, Mr. Paul Ackermann, Mr. Graham Lee, colleagues and staff at IDD Process & Packaging, Inc.

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March 1999.

[Deaeration, Blending & Carbonation Systems] [Grain Handling Systems] [Yeast Management] [Home Brewing Systems] [Tank Tops & Agitators] [C.I.P. Systems] [Flash Pasteurization - Theory & Practice] [Carbomat CO2 Analyzer] [FLASH PASTEURIZATION SYSTEMS]